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Jm/att
3/31/86

POTENTIAL HAZARDOUS WASTE SITE PRELIMINARY ASSESSMENT PART 1 - SITE INFORMATION AND ASSESSMENT		I. IDENTIFICATION	
		01 STATE	02 SITE NUMBER
		IL	046369328

II. SITE NAME AND LOCATION				
01 SITE NAME (Legal, common, or descriptive name of site)		02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER		
Freeman United Coal Mining Co.		Fidelity #11 NE Hwy 152		
03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE
Duquoin	IL	62832	Perry	145
08 COORDINATES		LATITUDE	LONGITUDE	08 CONG DIST
		325412.0	0891959.0	24
10 DIRECTIONS TO SITE (Starting from nearest public road)				
See Attached Map: >9500 acres in Duquoin Township T.6S, -R.2W.				

III. RESPONSIBLE PARTIES				
01 OWNER (If known)		02 STREET (Business, mailing, residential)		
Freeman United Coal Mining Co.		300 West Washington		
03 CITY	04 STATE	05 ZIP CODE	06 TELEPHONE NUMBER	07 TELEPHONE NUMBER
Chicago	IL	60606	()	()
07 OPERATOR (If known and different from owner)		08 STREET (Business, mailing, residential)		
Freeman United Coal Mining		Fidelity #11		
09 CITY	10 STATE	11 ZIP CODE	12 TELEPHONE NUMBER	13 TELEPHONE NUMBER
DuQuoin	IL	62832	()	()
13 TYPE OF OWNERSHIP (Check one)				
<input checked="" type="checkbox"/> A. PRIVATE <input type="checkbox"/> B. FEDERAL: _____ (Agency name) <input type="checkbox"/> C. STATE <input type="checkbox"/> D. COUNTY <input type="checkbox"/> E. MUNICIPAL <input type="checkbox"/> F. OTHER: _____ (Specify) <input type="checkbox"/> G. UNKNOWN				
14 OWNER/OPERATOR NOTIFICATION ON FILE (Check all that apply)				
<input type="checkbox"/> A. RCRA 3001 DATE RECEIVED: _____ MONTH DAY YEAR <input type="checkbox"/> B. UNCONTROLLED WASTE SITE (CERCLA 103 c) DATE RECEIVED: _____ MONTH DAY YEAR <input checked="" type="checkbox"/> C. NONE				

IV. CHARACTERIZATION OF POTENTIAL HAZARD				
01 ON SITE INSPECTION		BY (Check all that apply)		
<input type="checkbox"/> YES DATE _____ MONTH DAY YEAR <input checked="" type="checkbox"/> NO		<input type="checkbox"/> A. EPA <input type="checkbox"/> B. EPA CONTRACTOR <input type="checkbox"/> C. STATE <input type="checkbox"/> D. OTHER CONTRACTOR <input type="checkbox"/> E. LOCAL HEALTH OFFICIAL <input type="checkbox"/> F. OTHER: _____ (Specify)		
CONTRACTOR NAME(S): _____				
02 SITE STATUS (Check one)		03 YEARS OF OPERATION		
<input type="checkbox"/> A. ACTIVE <input type="checkbox"/> B. INACTIVE <input checked="" type="checkbox"/> C. UNKNOWN		BEGINNING YEAR _____ ENDING YEAR _____ <input checked="" type="checkbox"/> UNKNOWN		
04 DESCRIPTION OF SUBSTANCES POSSIBLY PRESENT, KNOWN, OR ALLEGED				
Heavy Metals (Toxic/Persistent/Soluble) Acids (Corrosive/Soluble)				
05 DESCRIPTION OF POTENTIAL HAZARD TO ENVIRONMENT AND/OR POPULATION				
Surface Water (Population/Environment) Ground Water (Population/Environment)				

V. PRIORITY ASSESSMENT				
01 PRIORITY FOR INSPECTION (Check one. If high or medium is checked, complete Part 2 - Waste Information and Part 3 - Description of Hazardous Conditions and Incidents)				
<input type="checkbox"/> A. HIGH (Inspection required promptly) <input type="checkbox"/> B. MEDIUM (Inspection required) <input checked="" type="checkbox"/> C. LOW (Inspect on time available basis) <input type="checkbox"/> D. NONE (No further action needed, complete current disposition form)				

VI. INFORMATION AVAILABLE FROM				
01 CONTACT		02 OF (Agency/Organization)		03 TELEPHONE NUMBER
				()
04 PERSON RESPONSIBLE FOR ASSESSMENT	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NUMBER	08 DATE
Richard M. Lange	EPA	RPM/PA-SI	217-782-6761	3 24 86 MONTH DAY YEAR





I HIGHLY VOLATILE
J EXPLOSIVE
K REACTIVE
L INCOMPATIBLE
M NOT APPLICABLE

EPA FORM 2070-12 (7-81)



POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT

PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE 02 SITE NUMBER
IL 046369-328

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☒ A. GROUNDWATER CONTAMINATION 02 ☐ OBSERVED (DATE _____) ☒ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Udt. 04 NARRATIVE DESCRIPTION

Rural pop. dependent on G.W.; Sparce

01 ☒ B. SURFACE WATER CONTAMINATION 02 ☐ OBSERVED (DATE _____) ☒ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Udt. 04 NARRATIVE DESCRIPTION

Must public supplies utilize surface water as source of
Supply. Extensive Recreational Uses of Surface water.

01 ☐ C. CONTAMINATION OF AIR 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ E. DIRECT CONTACT 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ F. CONTAMINATION OF SOIL 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 AREA POTENTIALLY AFFECTED: _____ (Acres) 04 NARRATIVE DESCRIPTION

01 ☒ G. DRINKING WATER CONTAMINATION 02 ☐ OBSERVED (DATE _____) ☒ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: Udt. 04 NARRATIVE DESCRIPTION

See A & B above

01 ☐ H. WORKER EXPOSURE/INJURY 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 WORKERS POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ I. POPULATION EXPOSURE/INJURY 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION



POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT

PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

01 STATE 02 SITE NUMBER
IL 046369328

II. HAZARDOUS CONDITIONS AND INCIDENTS (Continued)

01 ☐ J. DAMAGE TO FLORA
04 NARRATIVE DESCRIPTION

02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED

01 ☒ K. DAMAGE TO FAUNA
04 NARRATIVE DESCRIPTION (include name(s) of species)

02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED

Extensive Sport fishing industry in this area.

01 ☒ L. CONTAMINATION OF FOOD CHAIN
04 NARRATIVE DESCRIPTION

02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED

Consumption of sport fish.

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES
(Spills, runoff, standing liquids, leaking drums)
03 POPULATION POTENTIALLY AFFECTED: _____

02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY
04 NARRATIVE DESCRIPTION

02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs
04 NARRATIVE DESCRIPTION

02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING
04 NARRATIVE DESCRIPTION

02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED

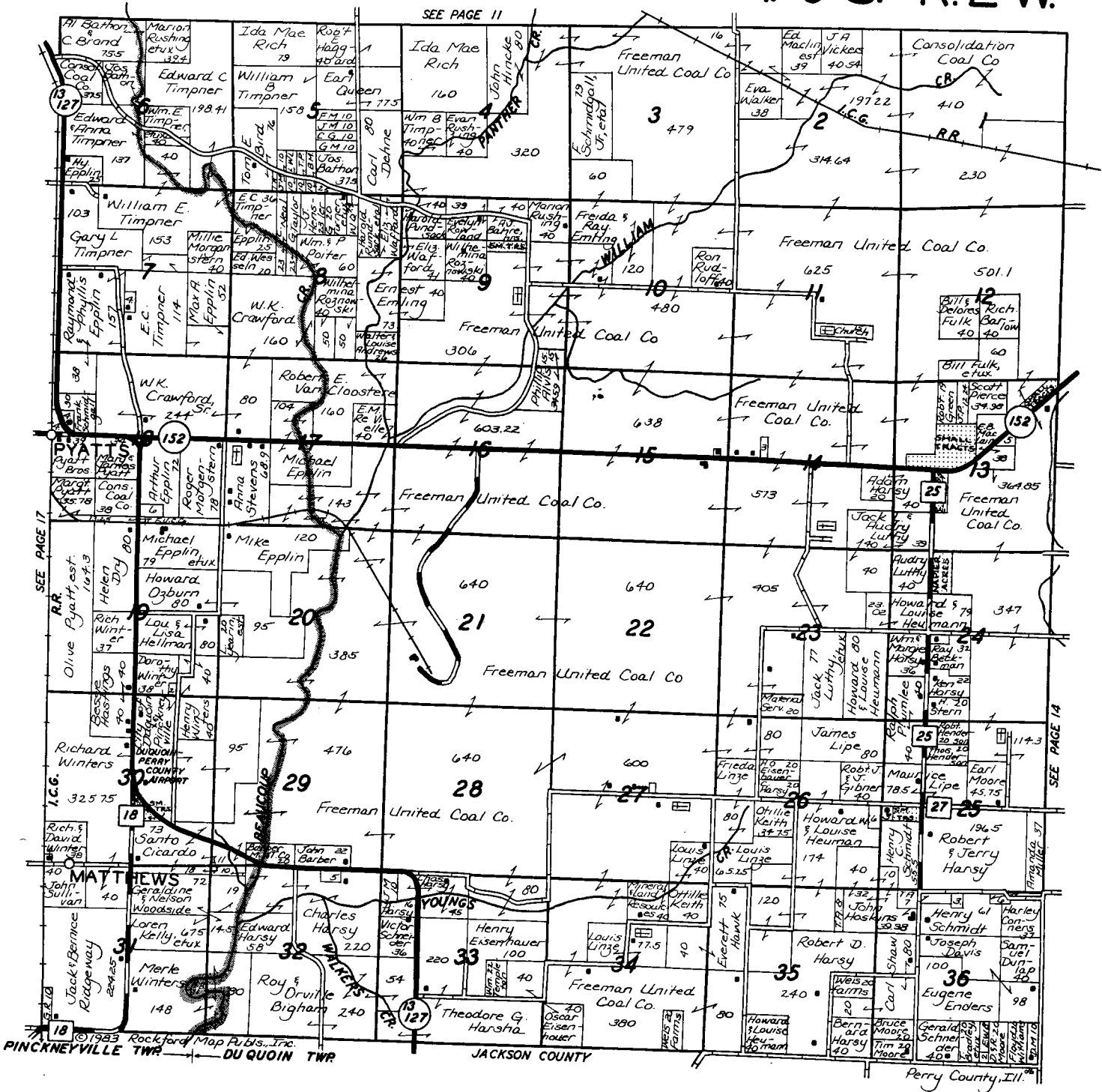
05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

III. TOTAL POPULATION POTENTIALLY AFFECTED: Und.

IV. COMMENTS

V. SOURCES OF INFORMATION (Cite specific references, e. g., state files, sample analysis, reports)

gs Part 2 Sect VI



EXECUTIVE SUMMARY

This site has been placed in the ERRIS/CERCLIS data base as a result of its identification during the Surface Impoundment Assessment (SIA). Certain other sites have recently been added to CERCLIS because of their similar ownership, operator, or proximity to an identified SIA site. The information contained in Section II Site Name and Location: items 01 thru 10 may be found to vary from the existing CERCLIS information; the information contained on EPA Form 2070-12 should be used henceforth as more accurately identifying the site name and location.

Information to complete Form 2070-12 has been acquired from a number of sources including, but not limited to, SIA printouts, CERCLIS, the Illinois State Reclamation Plan for Abandoned Mined Land, and county plat books. Considering the age of certain information, and the lack of specificity, some interpretation and judgement has been required in reporting all information. Where duplication of material with a moderate confidence level occurred, that information has been reported. Where conflicting data has appeared, the most current information with the highest degree of confidence has been used.

The materials of major concern at this location, with potential environmental impact, would be gob piles, acid mine drainage, and impoundments to retain mine drainage and coal wash plant process waters. Low pH and high iron concentrations have long been associated with mine drainage. Iron pyrites and marcasites (FeS_2) constitute approximately 25% of the mineral fraction of Illinois coals and thru a complex oxidation reaction yield H_2SO_4 and FeSO_4 providing the sources for low pH and Fe release problems. More recent concerns are being raised because of the heavy metal constituents of mine run coal, which are contained primarily in the mineral fraction and removed to the gob pile, with the pyrites, during initial processing.

USEPA publication EPA-650/2-74-054 summarizes work done by the Illinois State Geological Survey and raises points of concern for this area of Illinois. Pages 33 thru 50 of this report summarize analytical results obtained on four major Illinois coals and fractions of the coals obtained by specific gravity separation techniques. Looking at the Herrin #6 coal member, fractions of 1.60 specific gravity and greater, metals are reported in the following ranges.

	<u>Low</u>	<u>High</u>		<u>Low</u>	<u>High</u>
As:	23.0	244.0 ppm	Ni:	76	102 ppm
Cd:	4.8	152.0 ppm	Pb:	210	2162 ppm
Cr:	31	71.0 ppm	Sb:	2.8	12.0 ppm
Cu:	61	89.0 ppm	Se:	6.8	21.0 ppm
Hg:	0.68	3.80 ppm	V:	60	85 ppm
Mn:	74	457 ppm	Zn:	570	15170 ppm
Mo:	14	215 ppm	Zr:	21	32 ppm

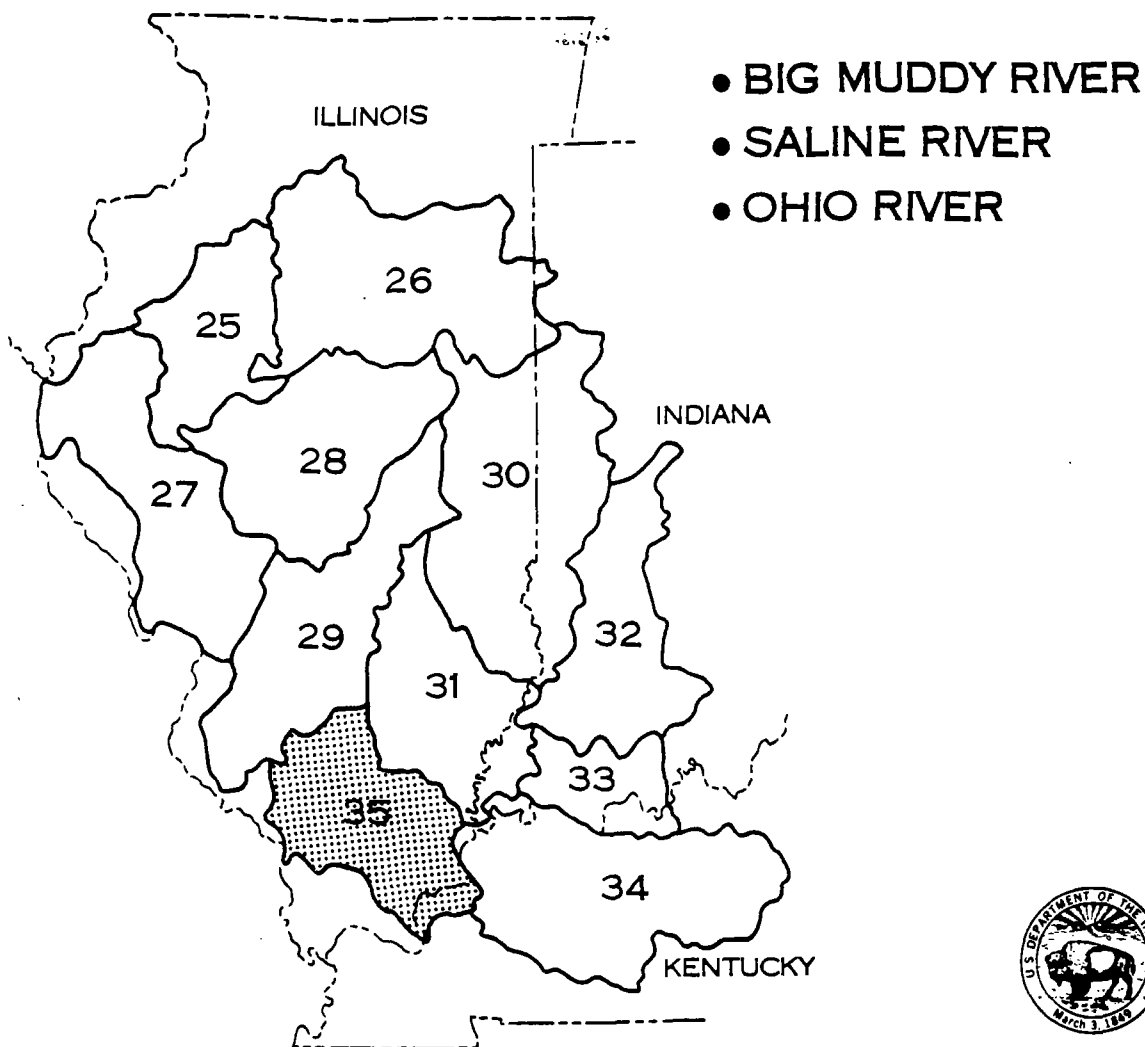
Comparing the above information against surface water quality data reported in "Hydrology of Area 35, Eastern Region, Interior Coal Province, Illinois and Kentucky" published by the U.S. Dept. of Interior, Geologic Survey; open file report #81-403, portions of which are attached, one begins to grasp the potentials for environmental degradation presented by mine drainage. In the USGS study, the maximum concentration of Ni found upstream of mining activity was 10 ppb, whereas downstream, the maximum value was 630 ppb. Mean values of Ni found were 6.1 ppb upstream, and 113 ppb downstream. The values for Ni represent a 63 fold increase of downstream maximum over the upstream maximum. Increases in the maximum concentrations of Cu were 27 fold, Zn at 32 fold, Mg at 11.9 fold, and Al at 2,238 fold increase.

The Illinois Department of Mines and Minerals and numerous private firms are involved in reclamation/remediation activities at a number of these sites. It is entirely possible that this site presents no hazard at this time, but the reverse is also possible. There is no evidence to indicate waste disposal, other than that associated with mine activity. A low priority has been assigned and site inspection activity should be considered on a representative selection of these sites on a time available basis. A higher priority was not assigned because of the regional scope of these sites and the high probability of existing remedial activities at high pollution potential sites.

RML:tk:4/8/49(3/21/86)

Attachment

HYDROLOGY OF AREA 35, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS AND KENTUCKY



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 81-403

HYDROLOGY OF AREA 35, EASTERN REGION, INTERIOR COAL PROVINCE, ILLINOIS AND KENTUCKY

BY

E.E. ZUEHLS, G.L. RYAN, D.B. PEART, AND K.K. FITZGERALD

**U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS 81-403**



**URBANA, ILLINOIS
MAY 1981**

8.0 SURFACE WATER (Continued)
 8.2 SURFACE-WATER QUALITY (Continued)
 8.2.4 IRON

IRON CONCENTRATIONS ARE HIGHER DOWNSTREAM THAN UPSTREAM OF MINING

Dissolved iron ranged from 0 to 640 micrograms per liter ($\mu\text{g/L}$) at sites upstream of mining and from 0 to 1,100,000 $\mu\text{g/L}$ at sites downstream of mining. Total recoverable iron ranged from 100 to 31,000 $\mu\text{g/L}$ at the upstream sites and from 0 to 2,100,000 $\mu\text{g/L}$ at the downstream sites.

Iron is the fourth most abundant element in the Earth's crust with 4.7 percent (Petrucchi, 1972). It is an important constituent of the surface and ground waters in this area because of its abundance in the sedimentary rocks of the Pennsylvanian System. Under natural conditions, in sedimentary rock and ground water, iron is found primarily in the ferrous form (Fe^{+2}). It is the abundance and the instability of ferrous iron, when exposed to air, that probably influence many chemical reactions downstream of mining. Surface-mining processes increase the amount of iron available to the system by exposing more surface area of iron-bearing minerals to weathering conditions. Geologic and erosional factors at sites upstream of mining maintain fairly stable concentrations of iron in streams.

At sites upstream of mining, the measured range of concentration for dissolved iron was from 0 to 640 $\mu\text{g/L}$ with a mean of about 110 $\mu\text{g/L}$. At sites downstream of

mining, concentrations of dissolved iron ranged from 0 to 1,100,000 $\mu\text{g/L}$ with a mean of about 20,000 $\mu\text{g/L}$ or approximately 20 milligrams per liter (mg/L) (fig. 8.2.4-1 and 8.2.4-2 and table 8.2.4-1).

Total recoverable iron for the sites upstream of mining ranged from 100 to 31,000 $\mu\text{g/L}$ with a mean of about 2,400 $\mu\text{g/L}$. Total recoverable iron for the downstream sites ranged from 0 to 2,100,000 $\mu\text{g/L}$ with a mean of about 37,800 $\mu\text{g/L}$ or approximately 38 mg/L (fig. 8.2.4-1 and 8.2.4-3 and table 8.2.4-2).

Concentrations of dissolved iron in surface water seldom reach 1 mg/L (American Public Health Association, 1976, p. 207). For the upstream sites, the entire range of values is well below this level. The surface water of areas downstream of mining sometimes exceeded 1 mg/L of dissolved iron.

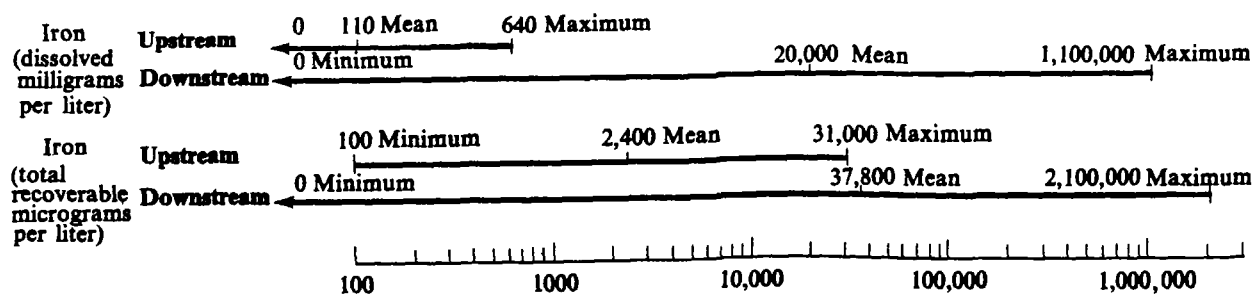


Figure 8.2.4-1 Range of dissolved iron and total recoverable iron concentrations measured at sites upstream and downstream of mining

8.0 SURFACE WATER (Continued)
 8.2 SURFACE-WATER QUALITY (Continued)
 8.2.5 MANGANESE

CONCENTRATIONS OF DISSOLVED AND TOTAL RECOVERABLE MANGANESE ARE HIGHER DOWNSTREAM THAN UPSTREAM OF MINING

Mean values of dissolved and total recoverable manganese concentrations were approximately 7 to 10 times greater at the sites downstream of mining than at the upstream sites.

Manganese is a common element widely distributed in igneous rocks and soils, but its total abundance in the Earth's crust is small enough to put it in the list of "trace" elements. Manganese and iron have similar electronic configurations and behave similarly. Because manganese has a lower affinity for oxygen, it stays in solution longer than iron (Rankama and Sahama, 1950).

For the sites upstream of mining in the study area, the measured concentrations of dissolved manganese ranged from 30 to 4,900 micrograms per liter ($\mu\text{g/L}$) with a mean of about 560 $\mu\text{g/L}$. This compares to a measured range of 20 to 91,000 $\mu\text{g/L}$ and a mean of about 4,100 $\mu\text{g/L}$ for the sites downstream of mining (fig. 8.2.5-1 and 8.2.5-2 and table 8.2.5-1).

Total recoverable manganese for the sites upstream of mining ranged from 30 to 3,900 $\mu\text{g/L}$ with a mean of

about 570 $\mu\text{g/L}$. Downstream of mining the measured values of total recoverable manganese ranged from 20 to 240,000 $\mu\text{g/L}$ with a mean of about 5,590 $\mu\text{g/L}$ (fig. 8.2.5-1 and 8.2.5-3 and table 8.2.5-2).

According to Rankama and Sahama (1950) the Mn:Fe ratio in natural carbonate waters is about 5:1. This ratio is approximated by the upstream data for which the mean dissolved manganese value was 560 $\mu\text{g/L}$ and the mean dissolved iron value was 110 $\mu\text{g/L}$. The mean values of dissolved manganese and dissolved iron for the downstream sites are 4,100 $\mu\text{g/L}$ and 20,000 $\mu\text{g/L}$, respectively, resulting in a Mn:Fe ratio of 0.21:1. This decrease in the Mn:Fe ratio reflects the relatively large upstream to downstream increase in iron concentrations compared to manganese concentrations.

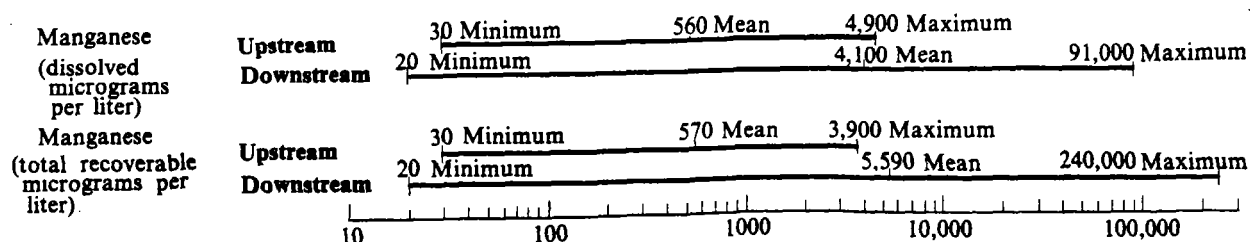


Figure 8.2.5-1 Range of dissolved and total recoverable manganese concentrations measured at sites upstream and downstream of mining

8.0 SURFACE WATER (Continued)
8.2 SURFACE-WATER QUALITY (Continued)
8.2.6 SULFATE

**SULFATE CONCENTRATIONS ARE HIGHER DOWNSTREAM
THAN UPSTREAM OF MINING**

Concentrations of sulfate ranged from 12 to 500 milligrams per liter (mg/L) at the sites upstream of mining and from 15 to 12,000 mg/L at the downstream sites. Sulfate concentrations at downstream sites can be estimated using the equation:
 $SULFATE = 0.64 (SPECIFIC\ CONDUCTANCE) - 210.$

Sulfur occurs in the coal and associated strata as metallic sulfides, mainly in the form of pyrite (FeS_2) and marcasite (FeS_2), which are also sources of ferrous iron. When oxidized, the sulfides yield the sulfate ion and ferric oxide. At the sites upstream of mining, the sulfates are probably introduced to the water from stream cuts through exposed Pennsylvanian rocks. This would be a fairly steady source of sulfate with erosion and oxidation contributing to the dissolution of sulfate materials.

The measured concentrations of sulfate at the upstream sites range from 12 to 500 mg/L with a mean value of 140 mg/L for all the observations at all the upstream sites. The upstream sulfate data contrast sharply with sulfate data for the downstream sites (table 8.2.6-1). The mean downstream sulfate value of 760 mg/L is larger than any value at an upstream site, and the maximum value of 12,000 mg/L is 24 times that of the largest value found at an upstream site (fig. 8.2.6-1). The minimum sulfate value of 15 mg/L at the downstream sites is approximately the same as the minimum at the upstream sites.

The contrast in sulfate concentrations between the sites upstream and downstream of mining, as seen in figure 8.2.6-2, suggests the higher sulfate concentrations downstream of mining probably result from the increased exposure of sulfide-bearing minerals to weathering in the mined area. Toler (1980) related annual sulfate loads to the area of surface mines as a percentage of total drainage area and showed that in southern Illinois sulfate can be used as an indicator of mine drainage (fig. 8.2.6-3).

For the sites downstream of mining a comparison was made between sulfate concentrations and specific conductance. There is a strong correlation (correlation coefficient = 0.93) between the two variables in the range for specific conductance from 400 to 5,000 $\mu mho/cm$ at 25°C. By using the regression equation represented by the line on the accompanying illustration (fig. 8.2.6-4), sulfate concentrations can be estimated at sites in the area downstream of mining from measurements of specific conductance between 400 and 5,000 $\mu mho/cm$ at 25°C.

8.0 SURFACE WATER (Continued)
 8.2 SURFACE-WATER QUALITY (Continued)
 8.2.7 ALKALINITY AND ACIDITY

ACIDITY VALUES ARE HIGHER DOWNSTREAM THAN UPSTREAM OF SURFACE MINING AREAS

Only one site upstream of mining had measurable acidity. Twenty-one sites downstream of mining had acidity values ranging from 0.1 to 99 milligrams per liter (mg/L) as the hydrogen ion (H^+). Alkalinity values ranged from 0 to 390 mg/L as calcium carbonate ($CaCO_3$) at the upstream sites and from 0 to 520 mg/L as $CaCO_3$ at the downstream sites.

Acidity is defined as "the quantitative capacity of an aqueous media to react with hydroxyl ions" and is expressed in mg/L as the hydrogen ion (H^+). It is an important parameter to measure in areas affected by surface mining because when present in significant amounts it is an indication that acid-forming materials are interacting with the surface water. Alkalinity is defined as the capacity of the solution to react with hydrogen ions and is commonly reported in mg/L as $CaCO_3$ even though $CaCO_3$ may not be the source of or be responsible for all the buffering capability.

One site upstream of mining had measurable acidity. Twenty-three of forty-eight sites downstream of mining had measurable acidity that ranged from 0.1 to 99 mg/L as H^+ (fig. 8.2.7-1 and 8.2.7-2 and table 8.2.7-1).

Alkalinity at sites upstream of mining ranged from 0 to 390 mg/L as $CaCO_3$ with a mean of 92 mg/L as $CaCO_3$. The sites downstream of mining had a range in alkalinity from 0 to 520 mg/L as $CaCO_3$ with a mean of 88 mg/L (fig. 8.2.7-1 and table 8.2.7-2).

Although mean values for alkalinity at the upstream and downstream sites are similar (fig. 8.2.7-3), variations between sites, especially downstream of mining, are great. Surface mining exposes not only the pyrites and marcasites (acid-forming materials) but also the limestones (source of $CaCO_3$) of the Pennsylvanian System. The variability of alkalinity values at the sites downstream of mining may depend on the amounts of limestone exposed during mining.

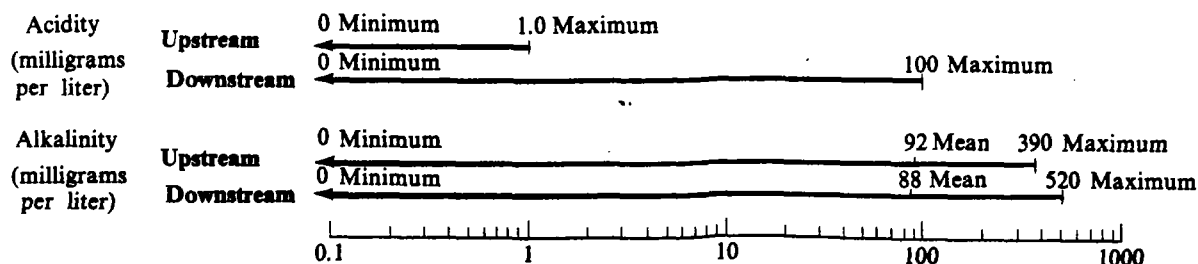


Figure 8.2.7-1 Range of acidity and alkalinity values at sites upstream and downstream of mining

8.0 SURFACE WATER (Continued)

8.2 SURFACE-WATER QUALITY (Continued)

8.2.8 TRACE ELEMENTS AND OTHER CONSTITUENTS

**CONCENTRATIONS OF TRACE ELEMENTS
VARY IN THE STUDY AREA**

Concentrations of many trace elements and other water-quality constituents differed between sites upstream and downstream of surface mining.

Concentrations of many dissolved constituents differed between sites upstream and downstream of mining as shown in figure 8.2.8-1. In water, copper, zinc, boron, calcium, nickel, magnesium, and aluminum all had higher mean concentrations downstream of mining than upstream. Concentrations of carbon dioxide in

water and total iron in the bottom material were also higher downstream of mining. Mean concentrations of total manganese in bottom material showed little difference between upstream and downstream sites. Dissolved chloride concentrations were less downstream than upstream of mining.

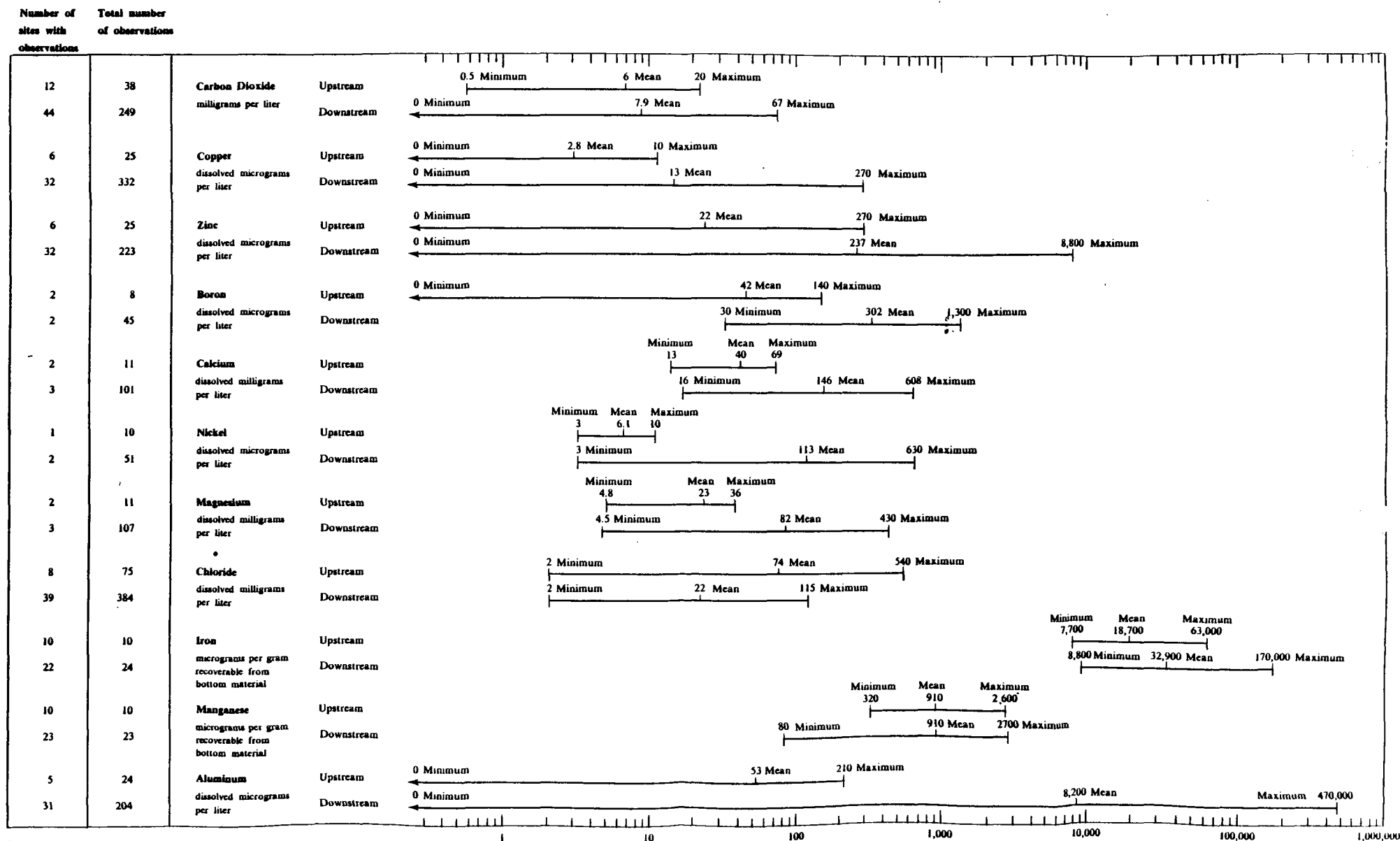


Figure 8.2.8-1 Range of concentrations for various constituents at sites upstream and downstream of mining.